Arnold Schwarzenegger
Governor

EVALUATION OF THE BENEFITS TO CALIFORNIA ELECTRIC RATEPAYERS FROM THE PUBLIC INTEREST ENERGY RESEARCH PROGRAM, 1998-2003

PIER FINAL PROJECT REPORT

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California Energy Commission
Public Interest Energy Research Program

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September 2004
CEC-500-2004-074

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Contract No. 500-02-014
Work Authorization No. WA-E2I-107

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ACKNOWLEDGMENTS

Many PIER staff members and contractors gave generously of their time in providing information about the PIER RD&D program and its products, without which this report could not have been completed. The authors thank all of them even though they number too many for individual mention. Particular thanks goes to Mike Magaletti, who provided oversight and guidance throughout the effort and who made sure that we had the resources and support to get the job done. The author also acknowledges the support of the Electricity Innovation Institute, the prime contractor to the Energy Commission under whom this work was performed. Dale Eldridge was particularly helpful throughout the work.

PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Residential and Commercial Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

What follows is the final report for the task *Development and Application of Benefits Analysis Methodologies to the Evaluation of the PIER RD&D Program*, performed under a subcontract to the Electricity Innovation Institute Contract Number 500-02-014 with the California Energy Commission. The report is entitled *Evaluation of the Benefits to California Electric Ratepayers from the Public Interest Energy Research Program, 1998-2003*. This project contributes to the overall PIER Program.

For more information on the PIER Program, please visit the Energy Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission s Publications Unit at 916-654-5200.

ABSTRACT

Fifteen new RD&D results were placed into commercial use during 2003 as a result of the PIER RD&D program. These products join eighteen products placed into commercial use prior to 2003 that continue to create benefits for California electric ratepayers. Benefits to California electric ratepayers were estimated based on projected applications of the products through 2008. The benefits are projected to be between $264 and $676 million, the range resulting from uncertainties in projected market success as well as in details of how the products will be used. From the start of the PIER program in 1997 through calendar year 2003, the total PIER program expenditures (contractor invoices paid, staff salaries, fringe benefits, overhead, supplies, etc) were about $200 million. The ratio of the projected benefits from PIER successes through 2003 to the costs through 2003 is between 1.3 : 1 and 3.4 : 1. We believe that the projected benefits are understated because available data were inadequate to develop credible estimates of three new items, the *Advanced Variable Air Volume (VAV) System Design Guide,* the *Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide,* and the *Monitoring Applications Based on Synchronized Phasor Measurements.*

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The 33 commercially successful products resulting from PIER RD&D through the end of 2003 are listed inTable 1. Items commercialized during 2003 are marked with an asterisk.

Table 1 PIER RD&D Products Commercialized Through 2003

Residential and Commercial Buildings End-Use Energy Efficiency
Berkeley Lamp
Commercial Kitchen Ventilation
Particulate Emissions Measurement for Unhooded Restaurant Appliances
Revised Residential Framing Factors
HVAC Duct Sealing Technique for Small Commercial Buildings
Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings
Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings
Real-Time Energy Management and Control Systems
Cal-Arch Energy Benchmarking Tool*
Hotel Bathroom Motion Sensor Night Light*
Bi-level Stairwell Fixture*

Advanced Variable Air Volume (VAV) System Design Guide*
Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide*
Design Guidelines for Skylights with Suspended Ceilings*
Industrial/Agricultural/Water End-Use Energy Efficiency
Cast Metal Industry Electricity Consumption Study
Selective Tartrate Removal System*
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Industrial Compressed Air System Energy Use Benchmarking Methodology*
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Energy Systems Integration
DG Interconnect Hardware
Real-Time Monitoring and Dynamic Rating System for Overhead Transmission Lines

Interconnection Standards for Small Distributed Generators
Improved Substation Seismic Design
Required Utility Buildings Seismic Vulnerability
Transmission Grid Monitoring Applications Based on Synchronized Phasor Measurements*

1 Introduction

1.1. PIER Programs

The Public Interest Energy Research (PIER) program is an electricity-related research program paid for by a surcharge on electricity to electric customers of investor-owned utilities in the State of California. The program was established in 1997, and the California Energy Commission (Commission) was given management responsibilities in 1998. Senate Bill 1038, which authorized continuation of PIER funding through 2006, requires that each year the Commission submit to the Legislature an annual report. "This report shall set forth the actual costs of programs or projects funded by the commission, the results achieved, and how the actual costs and results compare to the expected costs and benefits[1]". An evaluation of the benefits resulting from the PIER program from its beginning through the end of calendar year 2002 was completed in early 2003. The conclusion of that evaluation was that products then beginning to enter the market would generate benefits of two to five times the cumulative cost of the PIER program through 2002 based on applications of RD&D results over the five-year period 2003-2007. The evaluation was updated in early 2004. Fifteen new products were found to have attained some level of commercial success. An evaluation of the fifteen new products and and update of the previous evaluation are summarized in this report.

1.2. Approach To Benefits Analysis

An approach developed and used by the Gas Research Institute (now Gas Technology Institute) has been used to evaluate a set of PIER near-term RD&D results judged to have potentially high impacts in their target markets. The benefits are based on projected sales or applications of these products during their first five years of commercial availability. The benefits are based on side-by-side comparisons of the PIER products and their likely competitors in the market, and a net present value is calculated for the cash flow stream over the economic lifetimes of the products sold during the initial five years. The present values are generally based on reduced energy costs, reduced operating costs, or avoided or deferred capital expenditures.

1.3. Selection Of Successful Products

The terms "product," "product market," and "commercialized," or "commercially successful" are used throughout this document. How these terms are defined operationally determines the scope of our evaluation and even the types of benefits considered in the evaluation to a large extent. We summarize our use of the terms here to help the reader understand better our analysis.

We define "product" in a very general way. A product is simply a packaged RD&D result that is available to potential users. A product may be hardware, such as a new lamp; software, such as computer programs; a process or technique, such as a new energy measurement procedure; guidelines, such as design recommendations for a new building energy system; databases; and new information, such as a report designed to convey scientific findings to regulators or policy makers.

The term "product market" is defined in a way that is consistent with the definition of a product. The market may consist of customers who buy products through normal retail and wholesale channels; professionals who acquire information through published journals and professional or trade

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1California Senate Bill No. 1038, Ch. 515, Section 7: California Public Resources Code Section 25620.8.

organization publications (e.g., ASHRAE); companies and utilities, who use new products on behalf of their constituents and customers; regulators, such as the California EPA or the Energy Commission; policy makers and legislators; and the general public.

"Commercialized" or "commercially successful" within the context of this evaluation mean that the product is readily available to the intended product market though normal distribution channels and that the product has been put to use in such a way to create tangible benefits for the product user. In addition, except for very unusual circumstances, there should be a pattern of continuing use of the product for the foreseeable future (that is, the use should not be a one-time use by a single user). Our definition of commercially successful would include applications such as the use of information by policy makers or regulatory agencies, but would not include use of information by other researchers for research purposes.

2.0 Products Commercialized Between 1998 and 2002—An Update

An evaluation published in May, 2003[2] reported benefits of between $200 and $525 million in savings to adopters of 19 PIER RD&D products commercialized between 1998 and 2002. The analyses leading to this estimate of the benefits of PIER products commercialized through 2002 were revisited in early 2004 to update assumptions about product performance and sales or applications by adopters. The revised range of benefits is $207 to $526 million, about the same as was reported last year. One product, the Poultry Rinse Recycling, was found to be not available.

3.0 Products Commercialized in 2003

Fifteen new products emerged from the RD&D cycle in 2003. Descriptions of these products follow.

3.1. Residential and Commercial Buildings End-Use Energy Efficiency

3.1.1. Cal-Arch Energy Benchmarking Tool

This web-based software tool allows a commercial building operator to compare his building's energy use to the energy use of other buildings of similar size and location via a web-based application. The comparison is more accurate than previously available tools such as the Energy Star tools because it considers the population of California buildings (rather than regional or national samples) and is based on more accurate survey data. The building operator would typically follow up the results from this screening tool with a more detailed evaluation to determine whether efficiency improvements are in order and what those improvements might be. This free software is available online today. URL: http://poet.lbl.gov/cal-arch/benchmark.html

3.1.2. Hotel Bathroom Motion Sensor Night Light

The Lawrence Berkeley National Laboratory (LBNL) has documented the performance of a new lighting control system for application in bathrooms of existing hotels. In addition to conventional bathroom lighting, the WN-100 Motion Sensor Night Light control system incorporates a motion/timeout sensor calibrated to bathroom usage times and an automatic

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2"Evaluation of the Benefits to California Electric Ratepayers from the Public Interest Energy Research Program, 1998-2002," May 2003, Gerald D. Pine, Energy Commission Report P500-03-024F.

light-emitting diode (LED) night light. Testing was conducted at the Doubletree Hotel in Sacramento, where researchers confirmed a 46 percent reduction in bathroom light electricity use and a 40 percent drop in peak load when compared to conventional light switch usage. The WN-100 Motion Sensor Night Light can be purchased from The Watt Stopper. URL: http://www.wattstopper.com/products/details.html?id=96

3.1.3. Bi-level Stairwell Fixture

This project characterized the performance of and identified California code issues associated with a new bi-level light fixture developed by OccuSmart for use in stairwells, restrooms, laundry rooms, and other areas that require full lighting when occupied and minimal lighting when unoccupied. The fixture is a T8 lamp with the ability to provide 100 percent, 33 percent, 10 percent, and 5 percent output intensities. It is activated by an integrated ultrasonic motion sensor and has the potential to greatly reduce building energy consumption as well as peak energy demand. OccuSmart is currently selling three models and a total of seven different variant products. Although the product is currently selling in California, a significant increase in sales is likely to occur in 2009, when a product of this type will be required to satisfy Title 24. URL: http://www.archenergy.com/lrp/products/bilevel.htm

3.1.4. Advanced Variable Air Volume (VAV) System Design Guide

The design guide addresses the air side of built-up VAV systems in commercial buildings larger than 100,000 square feet. It was developed to promote efficient, practical, VAV system designs that advance standard practice, minimize life-cycle cost, and can be successfully implemented today. For buildings adopting the practices in the design guide, we estimate potential heating, ventilating, and air conditioning (HVAC) system electricity savings of 25 percent, corresponding to 12 percent of total building electricity consumption. This guide has been disseminated to designers and manufacturers of large HVAC systems. URL: www.energy.ca.gov/reports/ 2003-11-17_500-03-082_A-11.PDF

3.1.5. Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide

These guidelines recommend actions that architects, engineers, and design/building contractors can take to improve the energy efficiency of small HVAC systems, reduce operating costs, and improve indoor comfort and environmental quality. Researchers estimate that HVAC system operational losses could be reduced by 20 to 30 percent statewide if recommendations in this design guide were followed. This free guide is available online.
URL: http://www.energy.ca.gov/pier/buildings/projects/400-99-013-1-4.html

3.1.6. Design Guidelines for Skylights with Suspended Ceilings

These design protocols facilitate the use of skylights in buildings with suspended ceilings to minimize energy use while meeting all building requirements, such as fire protection, seismic safety, and acoustics. Following these guidelines will result in skylight/light-well systems that provide optimal energy performance and superior lighting quality. This free guide is available online. URL: http://www.energy.ca.gov/pier/buildings/projects/400-99-013-1-5.html

3.2. Industrial/Agricultural/Water End-Use Energy Efficiency

3.2.1. Selective Tartrate Removal System

The Selective Tartrate Removal System (STARS), developed by Eurodia Industrie S.A., uses an electrically driven membrane process to stabilize potassium and calcium tartrates during the wine-making process. It has the potential to supplant traditional cold stabilization methods used throughout the wine and juice industries. The STARS system has demonstrated an 80 percent reduction in energy use compared to traditional. Both stationary and mobile units can be obtained from Winesecrets. A mobile unit has been used by Winesecrets to process small batches of wine for the past year. Winesecrets predicts continued success of the mobile unit service and also expects to begin selling stationary units during 2004. A gradual increase in the market share for wine stabilization in California is expected as old cold stabilization units are retired. Depending on the general economic climate and the health of the wine industry specifically, growth of the market share of the STARS technology to 20-30% of the wine stabilization market in 5-6 years is possible. In addition, the technology is also expected to make inroads into the fruit juice stabilization market in the next few years. We have chosen to be conservative in our analysis, considering growth to about 10% of only the wine stabilization market in California during the next five years. URL: http://www.winesecrets.com/

3.2.2. Neutral Line Filter for Harmonics Reduction

Switching power supplies, such as those found in most computers and data centers, create harmonics that travel throughout a building's electrical distribution system, causing excessive power consumption in motors found elsewhere in the building. In turn, this excess consumption leads to overloads in the building's wiring and transformers. The EPRI Power Electronics Applications Center (EPRI PEAC) demonstrated that an harmonic filter installed in the neutral line of a three-phase power circuit in a Sacramento facility belonging to the California Franchise Tax Board could substantially reduce the harmful effects of the harmonics, reduce the air conditioning load, and reduce energy use by 4 to 6 percent. Based on the results of this demonstration, customers can confidently use the filters available from several vendors. Payback periods of two to three years are common in comparison to the costs of installing new transformers, wiring, or other equipment to handle the extra power flow from harmonics. Our analysis is based on results from tests of devices available from Harmonics Limited.

3.2.3. Industrial Compressed Air System Energy Use Benchmarking Methodology

Compressed air is the fourth largest utility cost (after electricity, natural gas, and water) in industrial operations. While air compressor efficiencies are well documented, energy use for the entire compressed air supply system (compression, storage, and distribution combined) is seldom measured. Southern California Edison (SCE) successfully developed a metric and a procedure to measure compressed air system performance and to compare its performance to other compressed air system installations. The approach involves measuring the electricity used by the system, the volume of air supplied, and the temperature and pressure of the air. The performance is summarized as the ratio of the air supplied in standard cubic feet per minute divided by the power input in kWh. This ratio has been named the CASE (Compressed Air Supply Efficiency) Index by SCE. The CASE Index provide a relative measure of system efficiency to help the operator judge the need for efficiency improvements. In addition,

continual monitoring of the Index provides an indication of the effectiveness of any system improvements and an early warning of developing problems. The Compressed Air Challenge (CAC) program of the U.S. Department of Energy provides detailed guidance to system operators for improving the efficiency of compressed air systems. One market study showed that 75% of compressed air system operators had no formal training in maintaining the systems, and that most operators were primarily concerned with keeping the system operating rather than improving its efficiency. We believe that the major contribution of the CASE Index will be in raising the awareness of system operators of the potential for efficiency improvements and and an increased in the proportion of operators that apply efficiency improvement measures recommended by the CAC program. SCE is conducting workshops, beginning in June 2004, to train energy managers and auditors in the measurement of the CASE Index.

3.3. Renewable Energy Technologies

3.3.1. Clean Power Estimator

The Clean Power Estimator, developed by Clean Power Research, LLC, provides California residential and commercial electric customers a personalized estimate of the costs and benefits of investing in a photovoltaic (PV) or small wind electric generation system. PIER funded development of a module for this software program that compares alternate roof options such as the addition of a radiant barrier, the use of high reflectivity materials (cool roof concept), or the use of roof systems with integrated PV cells. The software takes into consideration customer-specific information, such as location and electric rates, and provides an estimate of the costs and benefits of a PV or wind system. This web-based economic evaluation software, with the new module, is available from the Energy Commission.
URL: http://www.consumerenergycenter.org/renewable/estimator/index.html

3.3.2. PV Mounting Approach for Flat Roofs

The SunRoof™ FS system has no roof deck penetrations and, as a result, can be installed faster than competing systems, can be installed around roof objects, and can be tilted to increase electricity production. Furthermore, the system consists of interlocking panels that make it highly resistant to wind or earthquake damage, and it has a 25-year design life that meets or exceeds all industry standards. This competitive solution for PVs in the flat roof commercial market is now offered by RWE-Schott Solar.
URL:http://www.rweschottsolar.com/us/webseite.aspx?navid=136

3.3.3. Solar Power Integrated Roof Tile

One way to lower the costs of photovoltaic systems is to incorporate them into structural components such as the roof. The GE Solar Electric Home Power System is a roof tile with integrated PV cells that generates peak power of 55 watts at 8.4 volts. The tiles are manufactured to seamlessly integrate with MonierLifetile, Hanson, or Eagle Roof tiles, which are commonly used for residential roof applications. The tiles have a 25-year limited warranty on materials and workmanship. A home builder has announced plans to include the tiles as a standard feature in one development in the Sacramento area. The tiles are available from GE Energy, a division of General Electric Company.
URL: http://www.gepower.com/prod_serv/products/solar/en/prepkg_sys/resid_sys.htm

3.3.4. California Wind Energy Collaborative

The California Wind Energy Collaborative (CWEC), established at UC Davis in 2002, provides a California perspective that complements the nationally focused efforts of the American Wind Energy Association, the U.S. Department of Energy (DOE) National Wind Energy Program, and the National Renewable Energy Laboratory (NREL). Activities undertaken to date include research, development, system deployment, technical training, and technology and resource assessments. Major contributions of CWEC through the end of 2003 include (1) the establishment of a physical focal point for wind energy–related activities in California; (2) the development and maintenance of the California Wind Performance Reporting System, which tracks electricity capacity and production from wind as well as available technology; (3) the development of a statewide wind-engineering technician training program; and (4) a series of papers to evaluate wind resources and electric generation capabilities in California. URL: http://cwec.ucdavis.edu

3.3.5. California Wind Energy Resource Mapping

TrueWind Solutions, LLC developed a set of high-resolution maps of California that depict annual and seasonal averages of wind speed and wind power density. The wind speed and wind power density are displayed on a 200 meter grid. These wind resource maps are available in hard copy from the Energy Commission Cartography Office or electronically in JPG format on the Energy Commission website. In addition, an electronic interactive version is available, as are data sets that can be accessed through a geographic information system (GIS) application. These improved maps will encourage the development of wind energy in the state by helping companies and individuals identify promising wind project sites with a minimum of effort and cost. URL: http://www.energy.ca.gov/maps/wind.html

3.4. Energy Systems Integration

3.4.1. Transmission Grid Monitoring Applications Based on Synchronized Phasor Measurements

Conventional transmission electricity grid monitoring technologies take snapshots of the state of the system every four seconds. However, reliability-threatening transient phenomena can occur over much shorter time scales. The synchronized phasor measurement technologies developed by the Consortium for Electric Reliability Technology Solutions (CERTS) record observations many times per second, providing grid operators with this data in real time so that they can obtain a more accurate picture of the actual health of the grid. The California Independent System Operator (CAISO) is pioneering the application of this phasor technology and with the expectation that the technology will improve the CAISO's ability to maintain a reliable system. This tool has been in use at the CAISO for offline simu;ations for about one year. The Phasor Tool shows phase angle differences between various points on the system and a color-coded display green/yellow/red to display normal operation, marginal operation, and operation in the danger zone, < 30 deg., 30-70 deg. > 70 deg., respectively. This tool, in conjunction with other system monitoring tools being deverloped by CERTS, is expected to allow the CAISO to operate the system nearer the margins with confidence and avoid costly

measures to mitigate congestion problems. URL: http://certs.lbl.gov/pdf/SynPhasorAppGuide.pdf

4.0 Quantitative Benefits Results

The results of the benefits evaluation, combining an update of the evaluation of products commercialized through the end of 2002 and the evaluations of products commercialized during 2003 are summarized in Table 2.

4.1. Summary of Results

Evaluations of the 15 new PIER products and updates of the 18 products introduced prior to 2003 were performed using the procedure outlined in Section 1 and in Appendix B. For the 18 old products, the update included verifying that the product was still commercially available, verifying assumptions made in the 2003 analysis, updating sales forecasts, and updating the net present value calculations. The benefits generally changed very little from the 2003 analysis. The previously calculated benefits were dominated by the Residential and Commercial End-Use Energy Efficiency items related to Title 24, and our analysis of the projected benefits from these items did not change.

Evaluations of the 15 new products were also performed using the procedures outlined in Section 1 and Appendix B. Of the 15 new products, we were able to quantify benefits for nine. For the nine items, the projected benefits were $57 to 150 million. For the remaining six items, three deserve particular mention.

First, the *Advanced Variable Air Volume (VAV) System Design Guide* and the *Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide* are expected to be included in ASHRAE handbooks and recommendations. In addition, they are expected to support the implementation of Title 24 beginning in 2005 and to serve as the basis for more stringent requirements in the subsequent update of Title 24. Such future impacts would generate benefits on the order of tens of millions of dollars for each of these items. At the present time, however, we concluded that it is too early to project such benefits with confidence.

The *Monitoring Applications Based on Synchronized Phasor Measurements* is one of a suite of tools being developed for use by the CAISO (and other regional transmission grid operators) by the CERTS. The phasor tool has been used by the CAISO for offline simulations. Another CERTS tool, the *VAR-Voltage Management Tool*, is also being tested the ISO. These tools will join tools developed by CERTS previously (without PIER support) to provide near real-time monitoring and analysis of the state of the ISO system and a concise system-wide view that was almost impossible to get without the new tools. These tools are expected to provide an early warning of abnormal system operations and to increase the probability that operators will be able to intervene in time to avoid system collapses leading to electricity blackouts. In addition, the information should allow the ISO to improve the management of congestion on the transmission system and to reduce ISO expenditures to deal with congestion. The cost of a single large blackout in California has been estimated to be in the $1 billion range, and ISO has estimated that their expenditures for congestion will increase from an estimated $500 million in 2003 to about $1 billion in 2004. CERTS staff are convinced that the implementation of the suite of tools at the ISO will significantly reduce the probability of future blackouts. In addition, the tools are expected to reduce the cost to the ISO of managing congestion on the transmission system. We judged that it is too

early to include such benefits in our analysis because use of the tool for real-time applications is only in the initial phase.

Table 2 Benefits of PIER RD&D Products Commercialized Through 2003

Product	Use	Sales/ Applications in First Five Years	Range of Benefits ($ million)
Residential and Commercial Buildings End-Use Energy Efficiency:			
Berkeley Lamp	2001	5,000 to 60,000	$1 to 15 million
Commercial Kitchen Ventilation	2002	2,000 to 10,000	$14 to 71 million
Particulate Emissions Measurement for Unhooded Restaurant Appliances	2001	Not tracked	<$1 million
Revised Residential Framing Factors	2005	100,000 to 200,000	$2 to 6 million
HVAC Duct Sealing Technique for Small Commercial Buildings	2005	50 to 175 million sq. ft.	$40 to 120 million
Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings	2005	18 to 30 million sq. ft.	$61 to 102 million
Requirements for Skylight use in Low-Rise Residential and Commercial Buildings	2005	80 to 175 mill. sq. ft.	$63 to 139 million
Goettl Comfortquest Gas Heat Pump	2002	<100	<$1 million
Real-Time Energy Management and Control Systems	2002	Insufficient data	Not quantified
Cal-Arch Energy Benchmarking Tool	2003	*Insufficient data*	*Not quantified*
Hotel Bathroom Motion Sensor Night Light	2003	*80,000 to 200,000*	*$6 to 15 million*
Bi-level Stairwell Fixture	2003	*19,000 to 67,000*	*$5 to 17 million*

Product	Use	Sales/ Applications in First Five Years	Range of Benefits ($ million)
Advanced Variable Air Volume (VAV) System Design Guide	2003	*Insufficient data*	*Not quantified*
Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide	2003	*Insufficient data*	*Not quantified*
Design Guidelines for Skylights with Suspended Ceilings	2003	*0.3% to 1% of commercial buildings market*	*$3 to 9 million*
Industrial, Agricultural, and Water End-Use Energy Efficiency:			
Cast Metal Industry Electricity Consumption Study	2001	5% to 50% CA market	$0.5 to 5 million
Selective Tartrate Removal System	2003	0.15 to 1% of CA wine market	*$0.3 to $2 million*
Neutral Line Filter for Harmonics Reduction	2003	*$10 to $20 million in revenues*	*$20 to 40 million*
Industrial Compressed Air System Energy Use Benchmarking Methodology	2004	*11 to 15% of CA compressed air market*	*$5 to $27 million*
Renewable Energy Technologies:			
NO_x Control in Biomass – Fueled Boilers with Natural Gas Cofiring	2002	2 to 7 boilers	$0.2 to 1 million
PowerGuard® Solar PV Systems for Flat Roofs	2001	5 to 10 MW	$30 to 80 million (gross revenues)*
Clean Power Estimator	2003	*Insufficient data*	*Not quantified*
PV Mounting Approach for Flat Roofs	2003	*1.7 to 4.2 MW*	*$1.4 to 3.8 million*
Solar Power Integrated Roof Tile	2003	*1 to 3 MW*	*$0.5 to 1.2 million*

Product	Use	Sales/ Applications in First Five Years	Range of Benefits ($ million)
California Wind Energy Collaborative	2003	*Insufficient data*	*Not quantified*
California Wind Energy Resource Mapping	2003	*Used by all CA wind developers*	*$16 to $35 million*
Environmentally-Preferred Advanced Generation:			
Catalytica Xonon® Cool Combustion™ Catalytic Burner	2002	50 to 250 MW	$5 to 25 million
Energy-Related Environmental Research:			
Low NO_x FIR Burner for Gas Boiler	2002–2003	5 to 15	<$1 million
Energy Systems Integration:			
DG Interconnect Hardware	2001	Not quantified	Not quantified
Real-Time Monitoring and Dynamic Rating System for Overhead Transmission Lines	2000	Not quantified	Not quantified
Interconnection Standard for Small Distributed Generators	2002	500 to 2,000 kW	$4 to 17 million
Improved Substation Seismic Design	2002	N/A	$1 to 2 million
Reduced Utility Building Seismic Vulnerability	2002	100 buildings	$15 to 20 million
Transmission Grid Monitoring Applications Based on Synchronized Phasor Measurements	*2004*	*California ISO*	*Not Quantified*
[*] *Benefits not included in totals in discussions of results.*			

4.2. Discussion of results

The total benefits reflected in Table 2, which includes both the updates for the 18 products commercialized before 2003 and the 15 products commercialized in 2003, are estimated to be between $264 and $676 million. From the start of the PIER program in 1997 through calendar year 2003, the total PIER program expenditures (contractor invoices paid, staff salaries, fringe benefits, overhead, supplies, etc) were about $200 million. The ratio of the projected benefits from PIER successes through 2003 to the costs through 2003 is between 1.3 : 1 and 3.4 : 1. This compares to a range of $200 to $525 million estimated for the benefits of the 18 products commercialized through calendar year 2002 and evaluated in early 2003. The corresponding ratio of benefits to costs was between 1.6 : 1 and 4.2 : 1. (Based on a revised higher estimate for the total PIER expenditures through 2002, this range should have been between 1.3 : 1 and 3.5 : 1.)

The increase in benefits based on one more year of PIER RD&D is modest, partly because of the slower than expected penetration of previously commercialized PIER projects, and partly because available data were not adequate to develop quantitative estimates of benefits for three new PIER products that are likely to have substantial benefits. These items will be evaluated in the future as added and improved data become available.

5.0 Additional Products Nearing Commercialization in 2004

Several potential products had not succeeded in attaining commercial success through early 2004 but appeared poised to succeed sometime during the year. We describe those items here as a preview of things to come. The potential products are described, but no benefits estimates are provided.

Table 3 Products in Advanced Stages of Commercialization

Two-Stage, Indirect-Direct Evaporative Cooling System (IDEC)
Evaluation of the Utility System Capacity and Customer Demand Values of Photovoltaic Systems
Real-Time Dynamic Rating System for Electrical Transmission Lines
VAR-Voltage Management Tool
Global Climate Change Study: Impacts of Global Climate Change on California
Bird Fatality Reduction Methods in the Altamont Pass Wind Resource Area
California Biomass Collaborative

5.1. Two-Stage, Indirect-Direct Evaporative Cooling System (IDEC)

Developed by the Davis Energy Group this unit is more reliable, less costly, and more efficient than the previous SmartCool models. This IDEC system has annual energy savings of 89 to 95 percent over conventional cooling systems and a peak load reduction of 80 to 89 percent for typical California use. Davis Energy has received a letter of intent from an experienced manufacturer for licensing the technology. Further, "beta" tests of the technology in Sacramento Municipal Utility District (SMUD) sites will begin in July, 2004. URL: http://www.davisenergy.com/pdf/IFS0603.pdf

5.2. Evaluation of the Utility System Capacity and Customer Demand Values of Photovoltaic Systems

This report summarizes the benefits accruing to a utility from either utility or customer ownership of PV systems. The study evaluated benefits arising from reduced energy use; reductions or delays in the need for new transmission and distribution facilities; reduced exposure to volatile fuel prices; reduced emissions of criteria air pollutants; local capture of state, federal, or government incentive payments; and the creation of new business opportunities for the utility. By evaluating multiple scenarios and ranges of possible benefits for each metric, the report helps utilities identify market niches in which implementation of PV systems is profitable to both the customer and the utility, thus helping to encourage the market for PV systems. This report, prepared by Clean Power Research, LLC, is available from the SMUD.
URL: http://www.smud.org/pier/reports/S-034,%201.3.5.2,%2012-02,%20DEL(rev).pdf

5.3. California Biomass Collaborative

The California Biomass Collaborative was established in 2003 to enhance the development of sustainable and effective biomass energy systems for the state of California. Activities being undertaken by the collaborative include research, development, demonstration, and system deployment, as well as education and training. The activities of the collaborative complement the activities of the California Biomass Interagency Working Group. In addition to providing a focal point for biomass research activities in California, the collaborative has initiated the development of the Biomass Facilities Reporting System to track biomass electricity capacity and production and has distributed surveys to facility owners/operators. A series of resource and technology assessments are envisioned in the near future. URL: http://biomass.ucdavis.edu

5.4. Real-Time Dynamic Rating System for Electrical Transmission Lines

Frequently, the rated maximum allowable current flow through a transmission line is determined by line expansion and sag and the resulting clearance between the line and the ground or other objects. However, this rating method is generally quite conservative, resulting in an underestimate of the electricity that can actually be transmitted over that line. EDM, Inc. developed a system that monitors the position of a specific segment of a transmission line and uses that information, together with measures of environmental conditions, to calculate a real-time current rating for the line. Use of this technology will allow additional electricity to be transported over critical transmission lines during periods of peak demand. Benefits include deferral of new transmission lines and opening additional transmission paths during peak periods, increasing electric system reliability. The system was tested on

a segment of SCE's transmission system, where it performed as expected. Additional demos are being considered by SCE and SDG&E. URL: http://www.edmlink.com/sagometer.html

5.5. VAR-Voltage Management Tool

This tool replaces difficult-to-read and time-consuming tables of voltages at each monitoring point within the system with a visual, bird's-eye view of the overall health of the grid. Reliability coordinators and system operators get immediate access to critical information on system voltages over a wide area. This addresses a key problem facing operators today—data overload—and enables more effective and reliable management of operating margins. This tool has been delivered to CAISO and is being tested in preparation for connection to its system. In addition, CAISO is developing a state estimator tool that will use measured data on lower voltage (under 230 kV) lines, which is available at a limited number of locations, and network analysis to estimate data for other locations. The data from this estimator will be used as input for the VAR tool. The VAR tool will be tested during 2004. URL: http://certs.lbl.gov/RealTime_K1.html

5.6. Bird Fatality Reduction Methods in the Altamont Pass Wind Resource Area (APWRA)

Legal requirements and possible legal actions because of the numbers of fatalities of such birds as golden eagles, red-tailed hawks, burrowing owls, and other raptors threaten the continued operation of approximately 530 MW of wind power in the APWRA as well as the potential for 300 MW of additional capacity. The Energy Commission developed a risk sensitivity model for use by the wind industry in the APWRA to help reduce bird fatalities from collisions with wind turbines. Research results that relate site, turbine, and management conditions to expected bird fatality rates have been presented to the wind operators, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game. The researchers also recommended actions to reduce the number of fatalities and monitoring programs to verify the effectiveness of the recommendations. These recommendations are expected to inform the development of a mitigation plan by the wind industry and regulatory oversight by the U.S. Fish and Wildlife Service.

5.7. Global Climate Change Study: Impacts of Global Climate Change on California

Researchers from EPRI, Stratus Consulting, Inc., and Yale University have prepared a report examining the likely impacts for a range of climate change scenarios over the next century. Impacts considered included changes in precipitation and precipitation patterns, forest growth, habitats for California wildlife, energy use, coastal flooding, and human health. Personnel from the California Department of Water Resources (DWR) participated in the study. The PIER study was used to support the preparation of a section in the draft 2003 Update to the state Water Plan. The program is currently developing probability-weighted alternative climate change scenarios that DWR intends to use extensively in the ongoing preparation of its 2008 five-year plan.

6.0 Summary and Conclusions

Evaluations of the 15 new PIER products and updates of the 18 products introduced prior to 2003 were performed using the procedure outlined in Section 1 and in Appendix B. For the 18 old products, the update included verifying that the product was still commercially available, verifying assumptions made in the 2003 analysis, updating sales forecasts, and updating the net present value calculations. The benefits generally changed very little from the 2003 analysis. The previously calculated benefits were dominated by the Residential and Commercial End-Use Energy Efficiency items related to Title 24, and our analysis of the projected benefits from these items did not change.

Evaluations of the 15 new products were also performed using the procedures outlined in Section 1 and Appendix B. Of the 15 new products, we were able to quantify benefits for nine. For the nine items, the projected benefits were $53 to 150 million. For the remaining six items, three deserve particular mention.

First, the *Advanced Variable Air Volume (VAV) System Design Guide* and the *Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide* are expected to be included in ASHRAE handbooks and recommendations. In addition, they are expected to support the implementation of Title 24 beginning in 2008 and to serve as the basis for more stringent requirements in the subsequent update of Title 24. Such future impacts would generate benefits on the order of tens of millions of dollars for each of these items. At the present time, however, we concluded that it is too early to project such benefits with confidence.

The *Monitoring Applications Based on Synchronized Phasor Measurements* is one of a suite of tools being developed for use by the California ISO (and other regional transmission grid operators) by the Consortium for Electric Reliability Technology Solutions. The phasor tool had been used for the offline simulationin early 2004. Another CERTS tool, the *VAR-Voltage Management Tool*, is also being evaluated by the ISO in 2004. These tools will join tools developed by CERTS previously (without PIER support) to provide a near real-time monitoring and analysis of the state of the ISO system and a concise system-wide view that was almost impossible to get without the new tools. These tools are expected to provide an early warning of abnormal system operations and to increase the probability that operators will be able to intervene in time to avoid system collapses leading to electricity blackouts. In addition, the information should allow the ISO to improve the management of congestion on the transmission system and to reduce ISO expenditures to deal with congestion. The cost of a single large blackout in California has been estimated to be in the $1 billion range, and ISO has estimated that their expenditures for congestion will increase from an estimated $500 million in 2003 to about $1 billion in 2004. CERTS staff are convinced that the implementation of the suite of tools at the ISO will significantly reduce the probability of future blackouts. In addition, the tools are expected to help the ISO reduce its expenditures to manage congestion on the California electricity transmission system.

The total benefits reflected in Table 3, which includes both the updates for the 18 products commercialized before 2003 and the 15 products commercialized in 2003, are estimated to be between $264 and $676 million. This compares to a range of $200 to $525 million estimated for the benefits of the 18 products evaluated in early 2003. The increase in benefits based on one more year of PIER RD&D is modest, partly because of the slower than expected pentration of previously commercialized PIER projects, but primarily because available data were not adequate to develop quantitative estimates of benefits for three new PIER products that are likely to have substantial benefits, two design guides for

building systems and a phasor state monitoring tool for electrical transmission systems. These items will be evaluated in the future as added and improved data become available.

APPENDIX A: DESCRIPTION OF PRODUCTS COMMERCIALIZED PRIOR TO 2003

Appendix A—Descriptions of Products Commercialized Prior to 2003

Residential and Commercial Buildings End-Use Efficiency:

Berkeley Lamp. A table lamp with two compact fluorescent bulbs designed to be operated independently to provide task lighting, indirect lighting, or a combination of the two. This lamp is designed to provide a high efficiency alternative to overhead lighting in offices and torchiere lighting in residences. Marketed by The Light Corporation.

Commercial Kitchen Ventilation. Guidelines for installation of hoods and make up air ducting in commercial kitchens to minimize the undesirable interactions between the flow of make up air and the flow of air contaminated by cooking vapors into the hood. Proper location and design of make up air ducts allows greatly reduced hood air flows, which reduces hood fan power and losses of conditioned air from the kitchen. Information disseminated by the PG&E Food Service Technology Center.

Particulate Emissions Measurement for Unhooded Restaurant Appliances. Protocol and techniques for measuring the emissions of particulate matter from restaurant appliances. A standard protocol is provided to determine the need for a hood for a specific appliance, and this protocol is recognized by the UL-Witness Test. The measurement technique is the basis for a test cell and testing service for appliances that is offered by the PG&E Food Service Technology Center.

Revised Residential Framing Factors. Update of California Title 24 Building Efficiency Code to update default framing factors for residential new construction. The framing factors (area of window and door frames divided by total wall area) could be used in energy calculations to determine the required level of wall insulation. Updated framing factors are higher, resulting in more required wall insulation and reduced energy use.

HVAC Duct Sealing Technique for Small Commercial Buildings. Update to Title 24 providing a standard for sealing HVAC ducts in small commercial buildings. The new requirements are based on the success of an aerosol spray technique for the internal surface of the ducts. AeroSeal offers the spray technique as a commercial service.

Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings. Update to Title 24 requiring the placement of ceiling insulation for commercial buildings in contact with roof deck (interior or exterior) in most new buildings. Eliminates problems created by building renovations during which the integrity of the insulation is frequently compromised.

Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings. Update to Title 24 requiring the use of skylights with timers or light sensor controls in new commercial buildings with 25,000 square feet of open area directly under a roof and with a ceiling height of 15 feet or more.

Goettl Comfortquest Gas Heat Pump. Vapor compression heat pump driven by a natural gas engine and offered in sizes between 15 and 30 tons. Offers a low electricity use option for areas where electricity supplies are extremely constrained.

Real-Time Energy Management and Control Systems. Information monitoring and control system concept developed by Lawrence Berkeley National Laboratory to track the performance of large commercial HVAC equipment, diagnose troubles, and identify actions to increase operating efficiency. Concept was incorporated into commercial energy management and control software by Silicon Energy Corp. and by PowerNet Software.

Industrial, Agriculture, and Water End Use Energy Efficiency:

Cast Metal Industry Electricity Consumption Study. A study of energy utilization for metal melting operations in California foundries. The study consisted of a Foundry Energy Survey to collect information and establish a profile of California metal melting operations through an examination of energy usage and cost savings strategies. Implementation of the study's technical recommendations will result in savings in melting energy usage. The study was distributed to virtually all foundries in California.

Poultry Rinse Recycling. A water recycling system for chilled rinse water used in poultry processing plants. Specifically, the new recycling system eliminates the need for chlorination of chilled water and replacement of chilled water daily by using ozone to kill bacteria and hollow membrane filtration to remove foreign matter. This product is no longer available.

Renewable Energy Technologies:

NO_x Control in Biomass-Fueled Boilers with Natural Gas Cofiring. Adaptation to the California market of a technology developed by the Gas Technology Institute for gas cofiring of biomass-fueled boilers. Gas cofiring in the 5-15% gas range improves the power generation economics, reduces NO_x and CO emissions and allows operation of the plant at increased capacity compared to previous NO_x related limitations. This technology increases the plant turndown ratio, and improves the response of the electrical output to changing peak loads.

Environmentally-Preferred Advanced Generation:

Catalytica Xonon Cool Combustion™ Catalytic Burner. Catalytic combustion burner for small gas turbines that is designed to reduce NO_x emissions to 2 ppm. Several turbine manufacturers are integrating this burner into gas turbine systems.

Energy-Related Environmental Research:

Low NO_x FIR Burner for Gas Boiler. A forced internal recirculation (FIR) burner for use in natural gas boilers, developed by DOE and the Gas Technology Institute, and now being incorporated into a boiler line by Detroit Stoker. The new burner uses several techniques, including premixed stoichiometric combustion, internal recirculation of combustion products, and staged combustion with enhanced combustion uniformity. The advancement reduces both NO_x emissions (to < 9 vppm) and CO emissions (to < 40 vppm) without sacrificing efficiency.

Energy Systems Integration:

DG Interconnect Hardware. An inexpensive, Rule 21 compliant, solid state interconnection system to control grid-connected distributed generation systems. The interconnection hardware is offered commercially by EnCorp, Inc. as the Generator Power Control™.

Real-Time Monitoring and Dynamic Rating System for Overhead Transmission Lines. Real-time monitoring and dynamic rating systems for electric transmission lines designed to replace the current overly conservative power limits. These limits are based on worst-case conditions that lead to overestimating the maximum thermal sag of the lines on hot days with little wind. A new system has been developed by PIER and applied by the California ISO on the Path 15 segment connecting northern and southern California transmission systems.

Interconnection Standards for Small Distributed Generators. A common set of simplified procedures for reviewing and approving an application for a grid-connected distributed generator. Results to date (FOCUS-I) apply to cases where the DG unit is connected to the grid but does not supply power to the grid. A simplified review process has been developed that allows the DG applicant to bypass several stages of the previous review process if he meets certain minimal requirements, resulting in a labor saving by both the applicant and utility reviewers.

Improved Substation Seismic Design. Laboratory simulation of interconnected electrical substation components under earthquake conditions. Demonstrated that certain types of interconnections (rigid or spring-loaded) could create stresses on insulators or forces on transformers and other equipment that led to more damage than would occur for isolated equipment. Has led to changes in substation design guidelines and in component selection that would reduce the damage from an earthquake.

Reduced Utility Building Seismic Vulnerability. Development of new building structural performance simulation tools and design tools for use by utilities located in earthquake zones. Designs were developed that ensure employee safety and reduce the likelihood of outages caused by building damage without overly conservative assumptions. A comparison of old and new approaches to retrofit of existing buildings has demonstrated that significant savings will accrue to PG&E as a result of less conservative approaches to retrofit of three common building types.

APPENDIX B: APPROACH AND METHODOLOGY

Appendix B—Approach and Methodology

The approach used for this evaluation is based on an approach used by the evaluator to quantify the benefits of RD&D products resulting from research programs of the Gas Research Institute (GRI). The GRI program was very similar in structure and product mix to the PIER program, and it is expected that the techniques should be generally applicable to PIER products. Although it is expected that additional types of benefits will be considered in future analyses, this initial study focuses primarily on direct economic benefits of PIER products to product users. The basic steps in the process are summarized below.

For tangible commercial hardware or software products, the steps are:

- Identify products that have entered the market and verify that they are available for sale or distribution, that the manufacturer is committed to selling the product, and that the product is performing properly in user applications.
- Compile a list of all products that have entered the market through early 2003.
- Collect data that characterizes the product cost, performance, and features valued by users. The preferred sources of data are product vendors for cost information and data from users for performance and features information.
- Identify the typical product that the new product is replacing and collect analogous cost and performance information for that product.
- Estimate the economic lifetime of the new product.
- Obtain fuel price and other general economic data to use in calculating dollar value of energy savings or consumption and to make other cost calculations (e.g., labor costs).
- Develop a spreadsheet to calculate the annual dollar benefits that the product user receives by using the new product rather than the competing product. The calculation covers each year of the product lifetime and includes all differences in initial product costs, fuel costs, and operating and maintenance costs. Sales by year are explicitly included in the spreadsheet model. Calculations are based on constant (excluding inflation) dollars, and a net present value of the stream of annual incremental costs or savings is calculated based on a 5% discount rate.
- Collect data on actual product sales or distribution to date and project sales for the next five years. Product vendors or manufacturers are the preferred source of this data. Evaluate the credibility of this data and adjust based on past experience with similar products.
- Insert the product sales forecast into the spreadsheet model.
- Estimate a range of benefits for each product based on the spreadsheet analyses and augmented by use of uncertainties associated with future product sales and performance.
- Sum the ranges of the present values of benefits for all products evaluated and compare the resulting range to the present value of PIER disbursements over the past 5 years. This is an overall organizational benefit-to-cost ratio that can be used to provide a measure of benefits provided by the organization over a 5-year period. [This step applies only after all products have been evaluated.]

For RD&D with a primary product in the form of information rather than a tangible commercial product, the above approach is modified as follows:

- The use of the information by the user is evaluated to identify changes in decisions or in practices that result from using the new information. For example, a customer may change his purchase decisions or regulations, codes, or standards may be altered.
- The implications of the changes in decisions or practices are studied to identify economic consequences to the product users. Both annual economic consequences and the duration of the consequences are estimated.
- Annual economic savings are calculated for a typical user based on the economic consequences of the changed decisions.
- Rather than collecting vendor sales data estimates must be derived of the past and forecasted use of the information (number of uses per year).
- Calculations proceed as in the case of the tangible product. The number of annual uses of the information replaces the sales or applications estimates in step 8. The annual economic consequences of the changed decisions replace the benefits calculated in step 7. The duration of the economic consequences replaces the economic lifetime of the product used in step 7.